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Solid Rocket Motors
Thiokol Corporation

THE EVALUATION OF A DOUBLE PLANETARY MIXER FOR THE RTV SILICONE SRM NOZZLE BACKFILL OPERATION

FINAL REPORT

JANUARY 1990

Prepared for:

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GEORGE C. MARSHALL SPACE FLIGHT CENTER
MARSHALL SPACE FLIGHT CENTER, ALABAMA 35812

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Thiokol CORPORATION
SPACE OPERATIONS

P.O. Box 707, Brigham City, UT 84302-0707 (801) 863-3511

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FINAL REPORT

JANUARY 1990

Prepared by: T. C. Wardell

T. C. Wardell
Nozzle Processing

Approved by:

C. A. Russell
Integration Engineering

J. S. Clarke
SRM Program Management

J. G. Champneys 1/5
Supervisor
Nozzle Processing

I. N. Black
Test Planning and Reports

R. E. Lange
Nozzle Design

B. K. Perry 1/9/90
SRM Manufacturing Engineering

W. R. Williams
System Safety

F. Duersch Jr. 9 Jan 90
Reliability

K. M. Bailey 1-17-90
Nozzle Work Center Engineering

C. R. Whitworth, Manager 1/22/90
Materials and Processes

Thiokol CORPORATION
SPACE OPERATIONS

P.O. Box 707, Brigham City, UT 84302-0707 (801) 863-3511

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1.0 INTRODUCTION AND SUMMARY

SRM Program Office and Manufacturing Engineering requested that Process Engineering investigate the use of a double planetary mixer for the nozzle backfill operation. Briefly stated, the objectives of this study were:

1. To determine if the double planetary would provide a homogeneous airfree mix of the Dow Corning DC 90-006 two-part adhesive (Stock No. 7784).
2. To determine the impact on labor and material costs of incorporation of the double planetary mixer.
3. To explore methods of injecting the RTV into the RSRM nozzle joint from the mix bowl.

The double planetary mixer tested was equipped with a Teflon scraper blade, vacuum mix capability, and a dispensing system. The mixer provided an airless homogeneous mix of the DC 90-006-2 adhesive. The dispensing system tested provided low flow rates and pressure. Use of a dispensing system capable of increased pressure will be necessary.

Process Engineering recommends that the double planetary system with a Teflon scraper blade, vacuum mix, and an increased pressure dispenser be purchased and qualified for use on the RSRM nozzle backfill operation. We further recommend that the process be optimized to reduce material and labor costs associated with the RSRM backfill operation prior to qualification of the process change.

2.0 CONCLUSIONS

a. The double planetary mixer mixed the material completely after a one minute mix time.

b. The Teflon scraper blades removed all unmixed portions from the sides of the bowl.

c. Blade-to-bowl clearance (0.125 to 0.188 inches) allows thorough mixing of the material at the bottom of the bowl.

d. A small amount of base and catalyst at the top of each mixer blade is not properly mixed. Scrapedown of the mixer blades will be necessary during the middle of the mix time.

e. Vacuum mixing removes any air that is entrapped in the silicone prior to mix.

f. All samples exceeded a Shore A hardness of 35 after a seven day cure time as specified in STW5-2813C (paragraph 4.5.3.1 and paragraph 3.3).

g. None of the molded samples which were isolated from air contact for the first 24 hours met the Shore A hardness requirement of 20 after a 24 hour cure. However, all samples exceeded the Shore A hardness requirement of 25 after an additional cure time of 48 to 50 hours as specified in STW7-2865B (paragraph 4.2.1.2).

h. The automatic dispenser tested used 120 psi shop air to push a platen down into the bowl. This pressure was not high enough to backfill the Lexan joint all the way to the O-ring.

i. Use of a hydraulic system capable of producing more than 120 psi bowl pressure will be necessary to ensure that the dispenser provides adequate pressure to backfill all the way to the O-ring.

j. A cleanup time of 2 hours and 5 minutes was required for cleaning the mix bowl, mix blades, dispenser platen, and high pressure hoses. Most of the cleanup time was spent cleaning RTV from the inside of the high pressure lines.

k. The cleanup time of 2 hours 5 minutes could be reduced by use of a clean up station that included a solvent pump capable of producing turbulent flow in the high pressure line.

l. Cleanup time for the bowl and mixer blades can be significantly reduced by allowing the RTV silicone to cure on the blades and bowls and then peeling the cured material off.

m. Filling the Semco tubes that we currently use in the backfill operation directly from the bowl using the dispensing system is feasible using the same equipment.

3.0 RECOMMENDATIONS

It is recommended that;

a. A 1.5 gallon mix capacity double planetary mixer with Teflon scraper, dispenser, and vacuum mix capability be purchased for the RSRM backfill operation.

b. The dispenser have the capability to (1) fill the Semco tubes, and (2) fill the nozzle joint directly.

c. Use of the new double planetary mixer and dispenser be optimized prior to formal qualification.

4.0 DISCUSSION AND RESULTS

4.1 Problem Under Investigation

Uncured RTV in one of the flight nozzles produced concern as to whether the mixer currently used completely mixes the base DC 90-006 RTV with the catalysts. Air entrapment during the backfill operation is also a concern. The current method of performing the backfill operation is also time-consuming and wastes more that 50 percent of the material that is mixed. All of these concerns led Manufacturing Engineering and the SRM Program Office to seek a better way to perform the backfill operation.

4.2 Objectives of Investigation

Test objectives as outlined in ETP-0526 were to determine;

1. If the double planetary mixer is suitable for the SRM backfill operation.

2. The maximum flow rate of the automatic dispenser unit.

3. The time required for cleanup after the backfill operation with the double planetary mixer.

4. The thoroughness of mix using the double planetary mixer.

5. What optional equipment is necessary.

6. The operating parameters necessary for a successful backfill operation.

4.3 Plan of Investigation and Results

Tests on the double planetary mixer were run at Jaygo Inc. on 6 through 8 November 1989 with the Dow Corning DC 90-006 RTV silicone sealant. Three separate mixes were done:

1. The first mix used a double planetary mixer without vacuum and without a central dispenser.

2. The second mix incorporated use of both the central dispenser and vacuum during mix.

3. The third mix used a double planetary mixer without a central dispenser, but included applied vacuum during the mix.

During all three mixes, a Teflon blade rotated during the mix to remove any material trapped against the side of the bowl.

During all three mixes, visual examination of the base and catalyst was used to determine when the red base and green catalyst were completely mixed. Mixing with the double planetary mixer and no central dispenser showed a visual thoroughness of mix after 60 seconds of mix time. Use of the central dispenser reduced the amount of time required for all of the catalyst to be mixed into the base material to 30 seconds.

All mixes were mixed for a total of nine minutes which is identical to current manufacturing processes. This would give a safety factor of 9 for the mixer without the central dispenser and a safety factor of 18 for the mixer with a central dispenser. The cost of adding the central dispenser to the double planetary mixer is approximately $11,000. The extra cost of the central dispenser is not justified by saving 30 seconds in mix time for each backfill operation.

Samples were removed from each of the mixes for a determination of Shore A hardness. RTV silicone samples were placed in molds identical to those used on the line. A flat plate was used to press the RTV into the molds. The plates were left on top of the molds for the first 24 hours. An attempt to take Shore A measurements after 24 hours just after the top plates were removed revealed that the material was too soft to obtain a reading. Per Specification STW7-2865B, the samples were then cured for an additional 48 hours. After the additional cure time, all of the samples exceeded the cure requirement of Shore A hardness of 25.

The samples continued to cure until they reached a total cure time of seven days. Shore A hardness readings were then taken again. All samples tested above the minimum of 35 as required by STW5-2813C (paragraphs 3.3 and 4.2.1.2). The test data for Shore A hardness readings are shown in Table I.

TABLE I. Shore A Hardness

72 to 76 hour readings

	Mix 1			Mix 2			Mix 3				
	a	b	c	a	b	c	1st	2nd	3rd	top	bot
	40	38	39	41	42	41	41	38	35	38	32
	41	42	41	40	41	41	41	32	36	35	36
	39	42	41	39	40	41	41	32	32	36	32
	40	40	40	40	42	41	41	35	41	41	35
	40	41	41	40	41	41	40	38	35	35	45
Average	40	41	40	40	41	41	41	35	36	37	36
Std Dev	0.7	1.7	0.9	0.7	0.8	0.0	0.4	3.0	3.3	2.5	5.3

7 day readings

	Mix 1			Mix 2			Mix 3				
	a	b	c	a	b	c	1st	2nd	3rd	top	bot
	41	45	41	41	47	46	45	45	45	45	48
	41	43	43	43	48	46	43	45	45	46	45
	43	43	40	44	48	46	44	43	47	48	48
	40	41	45	44	48	45	46	45	44	50	48
	42	43	42	46	45	44	46	46	44	44	48
Average	41	43	42	44	47	45	45	45	45	47	47
Std Dev	1.1	1.4	1.9	1.8	1.3	0.9	1.3	1.1	1.2	2.4	1.3

Attachment I is a memo written by Michael J. Thomas giving the results of a statistical evaluation of the Shore A hardness readings. It compares the mean Shore A hardness values of the three test mixes performed at Jaygo Inc. against the values produced from historical data of actual backfill operations.

All three mixes had Shore A hardness mean values below the historical values indicated in Attachment I. Standard deviations were also lower for the test mixes on the double planetary mixer. This would indicate that the material will be slightly softer than the current material, but more predictable as far as hardness is concerned.

A Lexan joint was filled to simulate the RSRM backfill operation. Material from mix three was injected into the Lexan joint using 120 psi pressure on the platen in the bowl. This pressure pushed the RTV to within 1/4-in. of the O ring, but was inadequate to perform the job completely. This test showed that 120 psi bowl pressure was inadequate to fill the backfill joint to the O-ring. Dispensing of the RTV directly from the bowl will require pressure above 120 psi.

Use of a hydraulic system to push the bowl up into the platen would provide a bowl pressure of up to 500 psi. Placing the hydraulics below the bowl and shielding all hydraulic equipment would guarantee that even if the system were to leak, it would not end up in the RTV or on the nozzle itself. Jaygo has built several systems of this type in the past. Figure 1 is a sketch of such a system.

Another viable method for performing the backfill operation would be to mix the material under vacuum using a double planetary like the one tested. An automatic dispenser would then be used to fill Semco tubes and these tubes would be used to perform the backfill operation. This system would eliminate the need for a cleanup station and eliminate the need for cleaning the high pressure lines.

A time study was performed on the third mix. The third mix was chosen because many of the process bugs had been worked out by then. Table II provides the data taken from this time study.

TABLE II. Time Study

Work Description		Elapsed Time
Material weighup	start	09:00
	stop	09:200:20
Mix time	start	09:24
	stop	09:330:09
Ejection from bowl & sample prep	start	09:40
	stop	10:501:10
Cleanup	start	10:55
	stop	13:002:05

Review of the time study data shows cleanup time as 2 hours and 5 minutes. Over half of the cleanup time was spent cleaning the RTV from the inside of the high pressure hose which was attached to the mix bowl on one end and the backfill nozzle on the other. The hole had a 1/2-inch diameter hole and was 6 feet in length.

The hose cleaning method consisted of using high pressure air to blow the majority of the RTV out and then pouring solvent down the inside of the hose to clean it. This method is very time-consuming and needs further refinement.

If solvent were pumped through the hose with turbulent flow, it would clean the hose far quicker than pouring the solvent in by hand. This method was not tested. Figure 3 shows a simple diagram for such a system. A system of this type would allow the operator to clean the inside of the high pressure hose by first blowing the excess RTV out with shop air, then plugging the system into the solvent pump.

The man-hours required to clean the mix bowl and mix blades could also be significantly reduced by allowing the RTV to cure on the bowl and blades, then peel the RTV off and wipe the equipment down with solvent. This method would also have the advantage of producing a minimum of hazardous waste solvent.

Another method would be to fill the Semco tubes directly from the bowl. The Semco tubes would then be used to backfill the joints. This method would require less cleaning time than back filling the joint directly, but that would be offset by an increase in the time required to fill the Semco tubes. Figure 2 shows the equipment configuration for this system.

Both methods of backfilling the joint would require the same equipment with the exception of the high pressure hose and solvent cleaning station. To run the tests at the vendor, purchase of a high pressure hose was necessary. Purchase of the double planetary system with an automatic dispenser will allow us to either (1) backfill the nozzle joint directly, or (2) fill the Semco tubes and then fill the nozzle joint with the Semco tubes.

Process Engineering recommends the purchase of a 1-1/2 gallon mix capacity, double planetary mixer with a Teflon scraper blade and a high pressure dispenser. We also recommend that the equipment be brought on plant and that the process be optimized to gain maximum efficiency for labor and material use prior to qualification of the process change with a CTP.

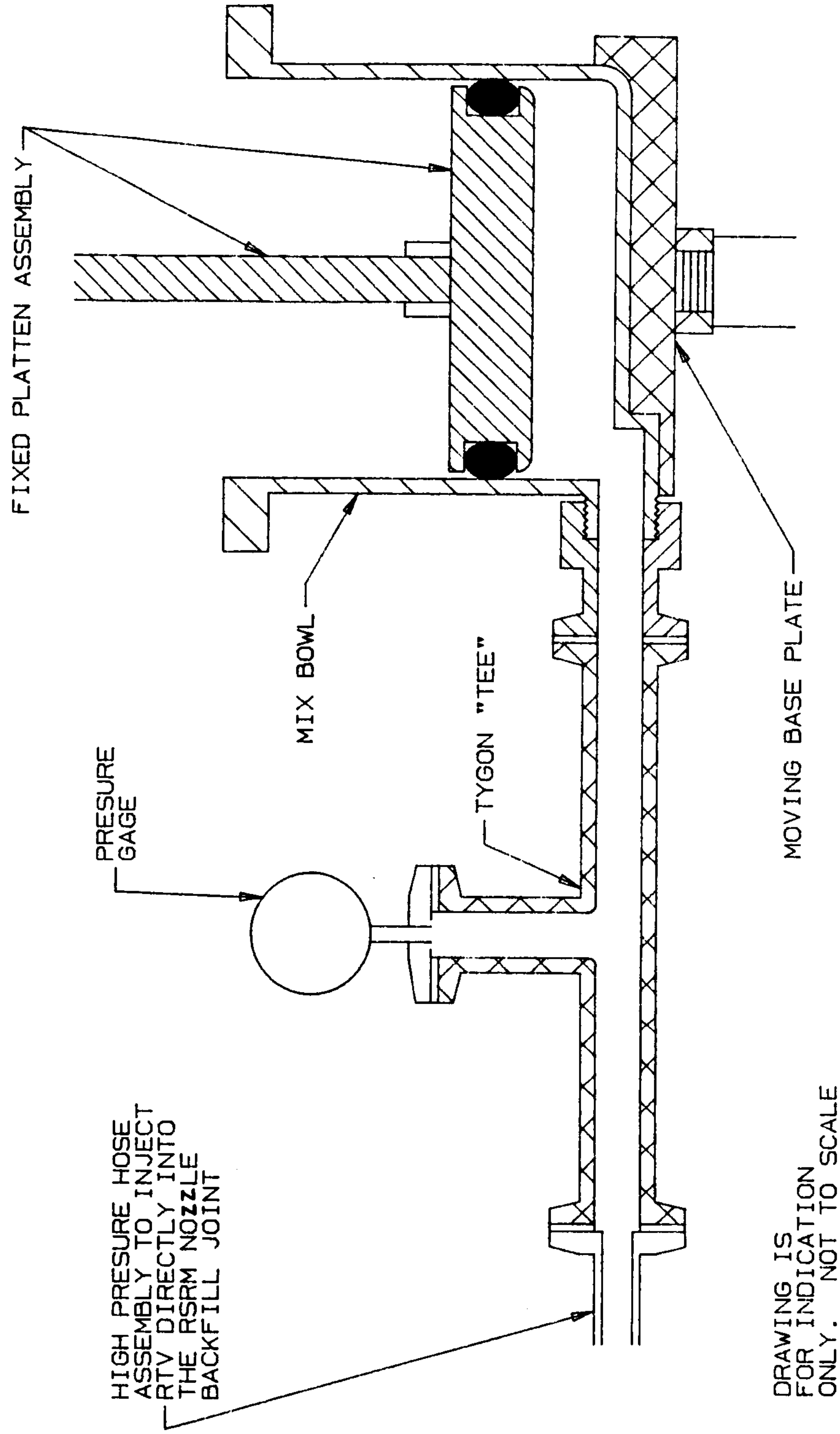

Figure 1. Discharge Directly To The RSRM Nozzle From The Mix Bowl

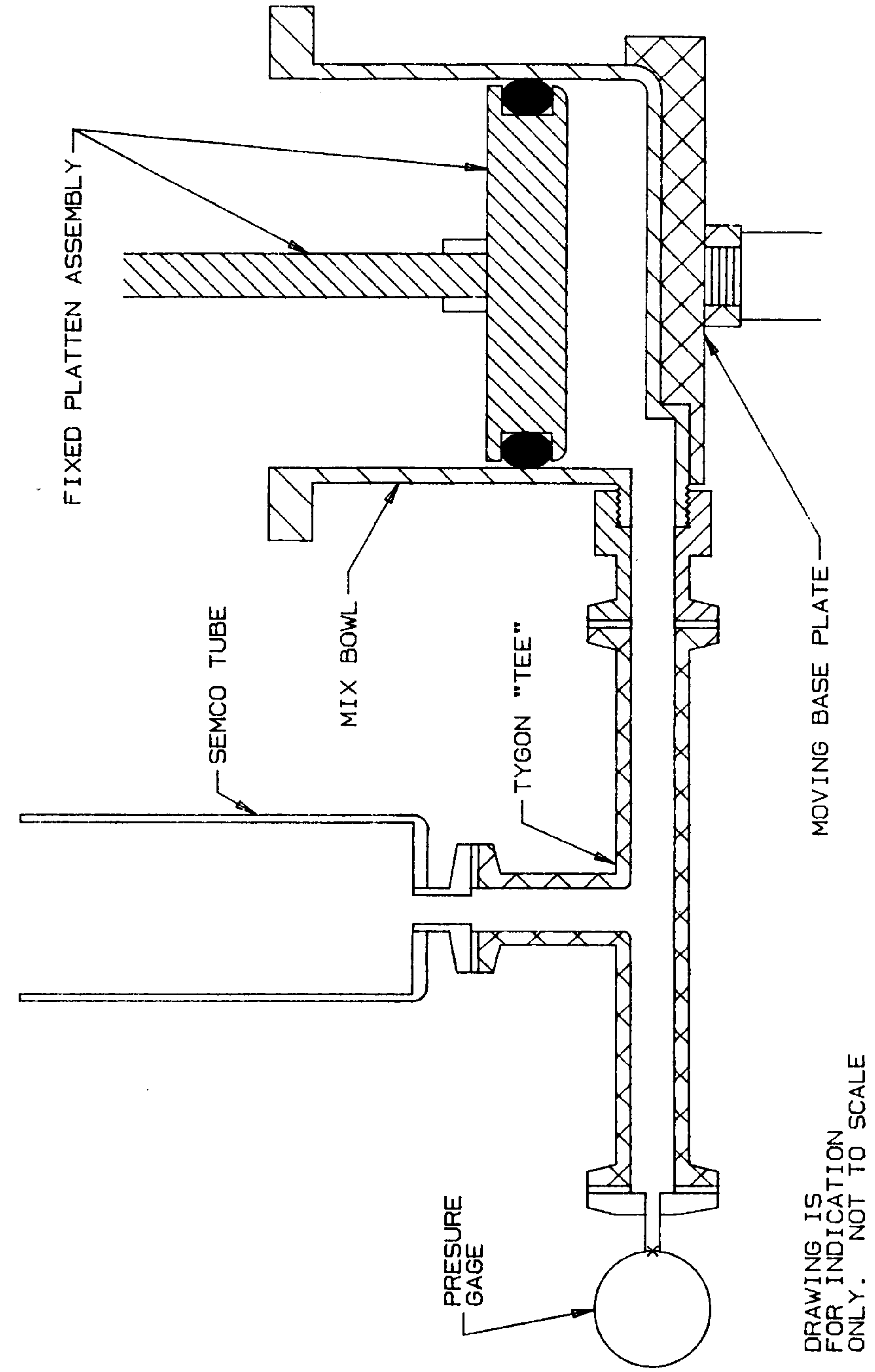

Figure 2. Discharge To SEMCO Tube From The Mix Bowl Configuration

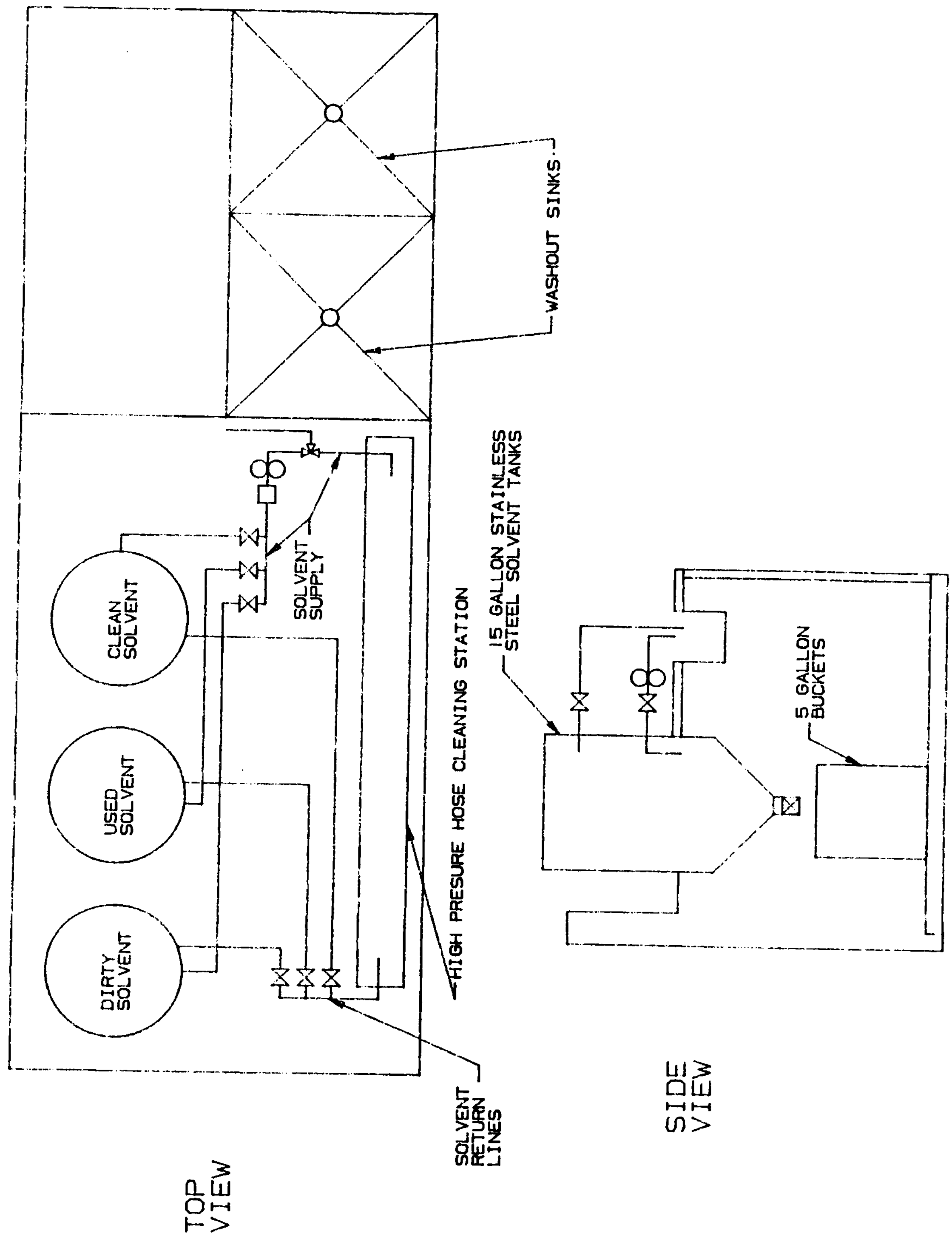

Figure 3. Cleaning Station

ATTACHMENT I. Memo FY90:L640:M050

Thiokol CORPORATION
SPACE OPERATIONS

15 December 1989
FY90:L640:M050

TO: Thomas C. Wardell
Process Engineering

CC: M. J. Oja, K. M. Bailey, J. O. Champneys,
T. F. Christensen

FROM: Michael J. Thomas
Analytical Methods Development

SUBJECT: Analysis of New Mixer Data DC-90-006 RTV

REFERENCES: Memo 1232-FY89-M181 From: M. J. Thomas To: M. J.
Oja Report TWR-19394 From: M. J. Oja
Memo 1621-FY90-M015 From: M. J. Oja To: R. Roth

In June of 1989 shore A hardness data for DC-90-006 RTV sealent was collected to support a specification change. This data was recorded in shop travelers under parts 1U52855-12 and 1U52861-12(901).

Shore A Hardness data for three experimental mixes processed in a new mixer was obtained from Tom Wardell for a comparitive analysis with the data recorded in June.

In response to your request a comprative analysis between the new mixer sealent shore A hardness data and the data collected in june 1989 was conducted using T tests.

The analysis showed that means for Mix 1, Mix 2 and Mix 3 were all statistically different when compared to the mean of 44.16 for the sealent data collected in June.

Mix	Mean	Standard Deviation
Mix 1	40.333	1.1127
mix 2	40.733	0.7988
mix 3	36.92	3.6733

ATTACHMENT I. Memo FY90:L640:M050 (Continued)

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In addition variances for Mix 1 and Mix 2 were statistically different when compared to the variance of 24.643 for the sealent data recorded in June.

Mix	Variance
Mix 1	1.2381
Mix 2	0.6381
Mix 3	13.4933

A T test also showed a significant difference in means and variances when all the mixes proccessed with the new mixer were grouped together and compared to the data collected in June.

Mix	Mean	Variance
sealent processes in new mixer	38.89	9.802
sealent data collected in June	44.16	24.643

The best estimates availible for the probability of a shore A hardness being 30 or less for the sealent processed in the new mixer are as follows:

Mix	T Value		Probability
Mix 1	-9.29		.0000001
Mix 2	-13.44	less than	.0000001
Mix 3	-1.88		.0361504

These probabilities were determined using the T distribution.
The output data used in the analysis is attached.

M. J. Thomas